Closure with Integral Gas Barrier

Technical Field

The present invention relates to closures with integral gas barriers. More specifically the invention relates to the field of closures for packaging for liquids that require a gas or humidity barrier. The invention is relevant in particular to the field of glass, plastics, including thermoformed plastics, or metal bottles or jars and unpressurised cartons.

Certain liquids, such as beer, are particularly susceptible to oxygen levels. The control of oxygen levels is also essential in aseptic and extended shelf life (ESL) packaging to prevent spoilage, tainting and discolouration due to the entry of oxygen.

The invention is therefore concerned with the control of gases within a container and, more specifically, the impact of the closure on this issue. A gas barrier is required to prevent both the escape of carbon dioxide from carbonated drinks packed under pressure, and the ingress of oxygen through the closure. Air can also be introduced into the container during a capping process.

Background Art

Crown cork caps that are crimped onto a glass bottleneck provide an effective packaging solution with excellent gas barrier characteristics.

Aluminium screw caps are also used with glass bottles. These have a post-applied liner material fitted to provide a seal. Another closure that relies on the gas barrier that metal provides is a ring-pull closure consisting of a metal cap moulded over the mouth and neck and provided at one edge with a ring-pull to enable removal. This closure is not reclosable. WO 03/022705 (Technocaps Limited - Mestriner) teaches the use of a plain metal sealing disk that is retained on a bead at the bottle rim by a plastics ring that can be removed by means of a tab. Again the Technocaps closure is not reclosable.

Screw-on metal closures are less suitable for use with plastics bottles as their use

requires high axial loading that would damage a plastics bottleneck.

Another option is to use a moulded closure with a loose multi-layered foil liner, which is inserted into the closure body. This assembly is applied after filling. The assembled closure is exposed to an induction energy field thus sealing the foil to the bottleneck. This foil seal provides a gas barrier. However, such loose foil seals are typically very difficult to remove and the closure system provides poor reseal performance once the foil element is removed. This solution is also not suitable for aseptic applications as microbes and contamination get trapped behind the loose foil liner. The cap sterilisation systems employed are unable to eradicate such contamination.

Developments in gas barriers for bottles, including scavenging agents added to PET polymers, mean that it is now practicable to use plastics bottles for products such as beer and other oxygen-sensitive beverages. However there is a need for a closure suitable for use with a plastics bottle that offers a high integrity gas barrier and is preferably reclosable.

Prior Art Solutions

A typical screw closure for use with a bottle is described in US4658976 (Aluminum Company of America - Pohlenz). A top seal is provided by means of a plastics liner in the top of the cap to seal against a rim of the bottle mouth. This type of cap is commonly used for mineral water and carbonated soft drinks.

The presence of a valve that seats inside a bottle mouth is a preferred solution for resealability in a reclosable plastics closure. A good seal is essential for plastics containers that have been processed in an in-line pasteuriser as this can result in heat-induced deformations of the bottleneck. A long valve is preferable to eliminate the leakage risk arising from this deformation.

Although Aluminum Company of America does not specifically address the gas barrier problem; others have used the same plastics liner or wad approach to address this problem. EVOH (ethylene vinyl alcohol) or rubber materials have been tried, but although these provide a gas barrier, they do not form good humidity barriers.

Owens-Illinois Closure Inc have, for example, announced a moulded-in liner seal that uses multiple thin layers of barrier material as described in US6399170 (Hock). This material tends to be expensive and brittle and is not well suited to function as a seal. Accordingly various designs have been suggested for use of such a barrier with other sealing structures. See EP-A- 1081 058 (Riffer) and US 2003/0057175 A1 (Willingham et al). These moulded liner sealers have been developed to provide gas barrier levels equal to or better than foil. While aluminium foil has excellent gas and humidity barrier properties, it is undesirable to allow exposed metal to come into contact with many products due to its propensity to cause corrosion under conditions of prolonged contact.

The problems of providing an oxygen barrier with a plastic or metal/plastic or metal closure are also discussed in WO 02/14171 (White Cap, Inc). An oil-free, single layer plastics liner is proposed as a liner to provide a gas barrier and also to act as a sealing gasket. Such a solution results in a closure that requires a high torque for removal if a good seal is to be achieved. Closures made of composite materials are also relatively expensive to produce. Sealing against a rim of the bottle mouth also requires the rim to be level and smooth. These conditions are not always possible after heat treatment.

In order to minimise the amount of oxygen entrained in a bottleneck during the capping process, it is usual for nitrogen to be continuously blown over the necks of the bottles. The inert nitrogen displaces any oxygen trapped in the neck of the bottle above the contents. However, the nitrogen does not displace oxygen that is trapped in the caps as it is lowered onto the necks. As a result a small but significant amount of oxygen is entrained and inevitably becomes trapped within the sealed bottles. This is a particular problem for screw cap closures.

Technical Problem

To provide a complete solution for gas-tight packaging in plastics containers that may have distorted necks, it is necessary to solve the technical problem of providing a reclosable, resealable closure with an integral gas barrier that can be fitted with minimal bottle top loading pressures during capping whilst being aseptic-compatible.

A further technical problem is presented by the need to prevent oxygen being introduced into the container when the closure is fitted.

Solution of the Invention

Instead of plastics liners and wads, the present invention provides a solution in which the advantages of an aluminium foil gas barrier are provided within a plastics cap. It is therefore possible to produce closures made from two materials, a plastics cap component and lightweight, flexible coated aluminium foil, in a variety of configurations that solve the technical problems identified.

The present invention provides a reclosable plastics cap having a top panel, a skirt and a plastics coated aluminium foil element fused to the cap to provide a gas barrier inhibiting gas flow through the cap, such that a peripheral aluminium edge of the foil element cannot come into contact with the contents of a container closed by the cap in use. This can be achieved by arranging the gas barrier on the top panel or sandwiched above a valve plate. New design possibilities are opened up by an appreciation that the gas barrier does not need to face the contents of the container to be effective.

Alternatively the present invention also provides a reclosable plastics cap having a top panel and a skirt, wherein a plastics-coated aluminium foil liner has a peripheral edge that is embedded and fused into a surface of the cap.

By using a plastics-coated liner with an embedded edge the contamination risk from an exposed aluminium edge is avoided. The key to the fusing of the edge into the cap lies in a realisation that with a suitable arrangement of sacrificial walls or the like in the component from which the cap is made induction heating can be employed to embed the edge completely without leaving any crevices that would prevent effective sterilisation of the assembly cap.

This type of cap may be used together with a valve to provide resealability. It can also be used with threaded or snap-on caps. The edge is preferably embedded into the internal surface of the top panel or of a valve of the cap, but may also be embedded into the external surface of the top panel or wrapped over the top of the cap and

embedded into the skirt. By fusing the edge into the material of the cap the same level of protection is provided as with the normal coating on the major surfaces of the foil.

The invention also provides a plastics component for use in manufacturing such a cap, wherein an annular wall extends from the top panel in order to define a recess to receive the foil liner. The recess can be beneath or on top of the top panel. Preferably the annular wall has an intermediate, reduced cross-section portion in order to enable a lower part of the wall to be folded back towards the top panel in order to retain the peripheral edge of the foil liner during production.

The invention also provides a reclosable plastics cap having a top panel, a skirt and a gas barrier to inhibit gas flow through the cap, characterised in that a closed plug substantially fills a void inside the cap and defines a valve adapted to fit inside and seal against an inner wall of a neck of a container to which the cap is fitted.

The present invention further provides a method of producing a cap from a plastics component comprising a top panel surrounded by a skirt, a receiving recess for a barrier foil, and a sacrificial wall, the method comprising the steps of placing a barrier foil into the recess and heating the wall to melt the plastic material of the wall in order to embed an edge of the foil into the cap.

The heating is preferably carried out by induction heating the foil to melt the wall, as this avoids contact with the cap and promotes clean and quick production.

Such a method is aseptic-friendly as the resulting cap has smooth surfaces and no additional crevices in which bacteria may escape when the cap is being rinsed and flushed.

Other features of the invention are defined in the appended claims.

Brief Description of the Drawings

In order that the invention may be well understood, four embodiments thereof will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Figure 1	shows a longitudinal half-section through a first embodiment of a cap shown incompletely assembled;
Figure 2	shows a detail of the cap assembly of Figure 1 during a first production step;
Figure 3	shows the same detail as Figure 2 in a finished cap after a second production step;
Figure 4	shows a longitudinal section through a second embodiment of a cap assembly;
Figure 5	shows the same section as Figure 4 during a first production step;
Figure 6	shows the same section as Figure 4 and 5 in a finished cap after a second production step;
Figure 7	shows a longitudinal, exploded section through a third embodiment of a cap assembly;
Figure 8	shows the same section as Figure 7 after the cap has been fully assembled;
Figure 9	shows a longitudinal section through a fourth embodiment of an exploded cap assembly;
Figure 10	shows the same section as Figure 9 after the cap has been fitted to the neck of a container or bottle;
Figure 11	shows a variation to a part of the component shown in Figure 9;
Figure 12	shows a longitudinal, exploded section through a fifth embodiment of a cap;
Figure 13	shows the same section as Figure 12 after the cap has been fully assembled;

Figure 14 shows a longitudinal section through a sixth embodiment of a cap; and

Figure 15 shows a longitudinal section through a seventh embodiment of a cap.

Detailed Description of Preferred Embodiments

A plastics cap 2 has a top panel 4 and a skirt 6. The cap 2 is intended for use with a PET container with a standard PCO[1] or BPF[2] (or any other standard) neck finish with typically a 28, 33, 38, 43 or 45mm neck diameter. It will be appreciated that the principle of the invention can be applied to other closures and diameters. However the embodiments being described are examples only.

Seven embodiments are described and in each similar parts are identified by like reference numerals.

Referring first to the embodiment of Figures 1 to 3, an inner wall 8 of the skirt 6 has thread formations 10. A lower edge of the skirt is connected by means of a breakable area 12 to a tamper band collar 14 that engages with and is retained on an external formation of the bottleneck in order to provide tamper evidence.

An annular sealing valve 20 depends from the top panel 4 inwardly of the skirt 6. The valve is positioned so that its outer surface 22 will seal against an inner surface of the bottleneck when the cap 2 is installed.

The plastics cap 2 as described thus far is conventional and readily available on the market.

The cap 2 of the invention is an assembly of the above described plastics component 28 with an aluminium foil barrier liner 30.

The foil liner 30 is positioned inside the valve 20. The liner 30 is a disc of foil having a peripheral edge 32. The disc 30 is cut from a sheet of plastics coated aluminium foil and therefore its peripheral edge 32 has exposed aluminium between two thin plastics

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[1] Plastics Closures Only – definition of a standard neck finish as used in the USA
[2] British Plastics Federation – definition of a standard neck finish as used in the United Kingdom

layers or membranes. The liner 30 is made of double-sided induction heat sealing (IHS) foil as described, for example, in GB237740A (Spreckelsen McGeough Ltd).

The term foil liner would normally be understood in the art to refer to a loose element. It will be appreciated that in this context the foil liner 30 will be welded into the cap 2 as described in detail below.

In order to enable the edge 32 to be embedded and fused into an internal surface 40 of the top panel 4, the cap is produced from an injection-moulded, plastics component that initially has a receiving recess 48 for the foil disc 30 formed by an annular sacrificial wall 50 depending from the internal surface 40 just inwardly of the valve 20. The wall 50 has an upper part 52 and a lower part 54 separated by an intermediate, reduced cross-section portion 56 that runs round the entire circumference of the annular wall 50. The lower part 54 terminates in an outwardly projecting flanged foot 58. The lower part 54 is designed so as to be able to be bent back up about a hinge provided by the reduced cross-section portion 56 so that it sits inside the upper part 52 with the foot 58 extending parallel to the internal surface 40 of the top panel 4 as shown in Figure 2. In this configuration the foot 58 retains the foil disc 30 in position.

During production, the plastics components 28 are inverted and a foil disc 30 is punched and placed into each plastics component 28 inside the wall 50. A tool is then brought down towards the panel 4. The tool face is shaped to engage with the lower part 54 of the wall 50 and fold it down over the edge 32 of the disc and then to further press down and heat (by way of induction) the assembly so that the plastics material of the wall 50 softens and flows over the edge 32 to embed it into the internal surface 40 of the top panel 4 as shown in Figure 3 fusing the plastics of the coating with the plastics of the component 28. This results in the foil liner 30 being welded on both sides to the plastics cap 2. The retaining of the disc step and the embedding step may be carried out as separate operations. The use of double-sided IHS foil allows the wall 50 to be melted indirectly by contact with the heated foil.

The foil discs 30 can be slightly dished to facilitate handling and aid accurate location.

The foil discs 30 may be sterilised prior to insertion in the recesses 48.

The foil discs 30 may have a smaller diameter than that of the neck of a bottle or container to which they are fitted. The foil liner may also cover the whole surface of the top panel 4 especially if externally mounted.

When the discs 30 are dropped into the recesses 48, they may be oversized and have the peripheral edge pressed down the inner surface of the sacrificial wall 50 in order to ensure that the gas barrier extends over the largest possible area of the top panel 4. If the portion of foil that extends down the wall is long, then the excess foil will need to be folded to fit. In this case the foil 30 and the component 28 must be passed through an aseptic sterilising rinser prior to assembly in order to maintain aseptic conditions. It is also possible to heat the foil sufficiently to enable the folded and wrinkled portions to be wholly embedded within the surface of the plastics component. A slightly oversized margin of a thin foil 30 can be smoothly sealed to the interior of the recess 48.

The caps 2 produced in this way can then be sterilised and passed to an aseptic filling line. It will be appreciated that due to the production process there are no remaining crevices in the internal surface 40 of the top panel such as may exist when a separate wad or liner is adhered to the internal surface 40.

It should be noted that the foil liner 30 is not welded to a spout or neck of the container or bottle, but is welded to the cap 2.

It will be appreciated that the term "embedding" refers to the position of the peripheral edge 32 relative to the final configuration of the top panel 4. In practice the foil may have one surface welded to the original surface 40 of the top panel of the component 28 and the other surface welded to the remnants of the sacrificial wall 50. In the second embodiment described below, the edge 32 is embedded into the internal surface of the valve, whereas in the third embodiment the edge 32 and the whole foil 30 is welded into the top panel 4. In the fourth embodiment, the whole foil is welded to the external surface of the top panel 4. In addition it would be possible to wrap the

foil over the cap and embed the edge in the skirt 6. However this is not a preferred option as foil on the side wall of the cap may be accidentally stripped if the caps are applied by means of a tool that grips the side wall. Foil in this position would also cover the knurling typically provided on the external surface of the skirt 6 to facilitate gripping of the cap 2 when it is opened and closed. In all these embodiments the plastics coating of the foil 30 is fused with the plastics of the cap component 28.

Variations

Caps 2 may also be produced without a valve 20, or with valves that can be as long as necessary to provide resealability against distorted bottlenecks. As illustrated in Figures 1 to 3, the valve 20 is an open-ended cylindrical wall. As the depth of the valve increases there is scope for it to entrain air, which is drawn into the bottleneck when the cap is fitted. This can be avoided by closing the open end of the valve as described in more detail in the embodiments of Figures 11,14 and 15 below.

The sacrificial wall 50 may have other configurations that will nevertheless allow it, in conjunction with a suitably shaped tool, to sacrifice the material from which it is formed into an embedment for the edge 32 of the foil disc 30. A tapered wall, L – shaped wall 50 or a thin wall bent over at the base may be possible.

Second Embodiment

In the second embodiment as illustrated in Figures 4 and 5, the sacrificial wall 50 is formed as an extension part 54 of the valve 20 itself. The annular part 54 is separated from an end of the valve by a reduced cross-section portion 56. In this embodiment the recess 48 is the whole of the space within the valve 20. During production the part 54 is folded inwardly against an inner wall of the valve 20 as shown in Figure 5. After heating through the IHS foil 30 the edge 32 of the foil disc 30 becomes embedded in the cap and more specifically into the wall of the valve 20.

Third Embodiment

In the third embodiment as illustrated in Figures 7 to 8, the cap 2 is made of a component 28 and a second component or valve plate 60 formed in the shape of a

circular plate 62 that carries the valve 20.

The component 28 has a top panel 4 that is thinner than normal in order to define the barrier-foil receiving recess 48 that also receives the plate 62 of the second component 60. The recess 48 is defined by a wall 64 inside the top panel. A central part 66 of the top panel 4 need not be present in order to reduce overall weight in applications where the foil itself has sufficient pressure-retaining capability to maintain the structural integrity of the cap 2. A central hole or opening 66 that exposes the foil 30 and corresponds to a hole 68 in the plate 62 can be used to allow the consumer to puncture the cap with a straw for consumption of the contents without opening of the cap. Where only weight saving is required the plate 62 can have a solid top. The central hole 66 may be larger than shown provided there is a sufficient recess 48 to hold the foil disc 30 during assembly. The plate 62 may also have a central opening 68 when there is no corresponding opening in the top panel.

In order to assemble the third embodiment, the disc 30 is placed in the recess 48 and trapped in position by the plate 62. When the foil is heated by induction heating the plastic material of the plate 62 and wall 64 acts in the same way as the sacrificial wall and embeds the foil in the cap fusing its plastic coating with the material of the cap component 28.

Fourth Embodiment

In the embodiment of Figures 9 and 10 the cap 2 is made of an annular cap component 28 and a circular valve plate 60 formed in the shape of a circular plate 62 that carries the valve 20. The foil liner 30 sits on top of the plate 60.

The component 28 has a top panel 86 that defines a central hole or opening 88 that has a diameter smaller than the diameter of the plate 62. The cap 2 is part-assembled prior to fitting to the spout or neck of the container or bottle. As shown in Figure 9, the plate 60 is fitted to the component 80 and held in place towards the base of the cap 2. This can be achieved by resting on an inwardly facing flange (not shown).

As the plate 60 is at the base of the cap component 28 when the cap is fitted there is

no significant volume of air that is entrained when the cap 2 is fitted to the neck of a container or bottle. As the cap 2 is screwed onto the neck the plate 60 moves upwards in relation to the skirt component 28. When the plate 60 abuts the top panel 86 the foil 30 trapped against the panel 86. The cap is induction heated to embed the foil between the plate 62 and the top panel 86 as shown in Figure 10.

Variations

As shown in Figures 11a to 11c the foil 30 may be fitted over an open-end face of the valve 20 on the base of the plate 74. In Figure 11a, the edge of the foil 32 fits between the valve 20 and a sacrificial wall 50. Induction heating causes the material of the sacrificial wall 50 to flow over the edge 32 embedding it in the material of the valve plate 60. In Figures 11b and 11c the foil extends out to the edge of the valve plate 62 or may be wrapped round it.

These variations further reduce the amount of oxygen entrained when the cap 2 is assembled to the neck as the small amount trapped in the space defined by the valve 20 is also eliminated.

Fifth Embodiment

In the embodiment of Figures 12 and 13 the recess 48 is located on an external surface 70 of the top panel 4 and is surrounded by a protruding sacrificial wall 50. The foil disc 30 is dropped into the recess 48 and then heated by induction. The contact between the edge 32 of the foil and the sacrificial wall 50 causes the material of the wall to flow over the edge sealing the disc 30 securely to the top 70 of the cap so that it cannot be removed. The use of a gas barrier on top of the cap allows the foil 30 to cover an even larger portion of the surface. This means that any gas that is to pass through the cap must pass along a tortuous and long path within the plastic of the cap to avoid the foil. This results in very low levels of gas transmission.

While embedment of the edge 32 is not essential in this embodiment for avoiding contamination of the contents, the foil liner 30 must be welded to the top panel 4. Fusing of the entire foil disc to the panel will prevent the foil being removed during

transport.

Sixth and Seventh Embodiments

In the embodiments of Figures 14 and 15, a large plug 92 fills nearly all of an internal space within the cap 2. This plug 92 also forms in its upper part the valve 20 for sealing against an internal surface of the neck of the bottle or container to which the cap is fitted.

In Figure 14 the cap component 28 is moulded to create a deep recess 90 in the top panel 4. The valve 20 is formed by an upper portion of side walls of the recess. A lower part of the plug 92 can have a reduced diameter relative to the valve to aid insertion. The plug could also be tapered.

The foil 30 is seated in a recess 48 formed in the top panel 4 and is embedded as described in relation to the earlier embodiments of Figures 12 and 13. The welding of the foil 30 to the cap component 28 is carried out in a nitrogen environment so that the recess 90 is filled with this inert gas.

It will be appreciated that a cap component 28 having a plug 92 cannot be moulded in one piece with a flat top panel. It is unacceptable to leave the recess exposed as it would attract dirt and become contaminated. Closing it by means of the foil disc 30, which seals in the nitrogen atmosphere, provides an elegant solution to this problem. Moreover, the foil liner 30 is not directly exposed to the pressure of the contents of the container but is supported by the plug structure. It is therefore possible to use a lightweight, flexible aluminium foil for this purpose, as it is not under pressure.

In the embodiment of Figure 15, the foil 30 forms a closure for an open end of the plug 92 and is embedded and fused into the valve wall by means of a sacrificial wall 50 which depends downwardly from the valve wall 20 to provide a slot into which the edge 32 of the foil can fit prior to being fused into the slot by means of induction heat sealing. The void inside the plug 92 is filled with nitrogen or other inert atmosphere.

In both these embodiments the application of the cap to the bottleneck introduces the

smallest possible amount of entrained air. Therefore this cap retains as much as possible of the inert atmosphere in the neck space above the contents as is possible.

Variations

Rather than simply extending across a top of the deep recess 90 the foil 30 may be used to line the recess 90. The recess may be left empty, but is preferably filled with other decorative material to avoid trapping dirt and representing a hygiene risk. Alternatively a foil may be placed across the deep recess 90 and the interior lined with EVOH or other similar gas barrier plastics materials.

General Variations

Scavenger chemicals may be added to the material of which the cap is moulded or added to the foil membrane or a scavenger coating may be applied to the inner surface of the cap 2. It is also desirable to use oxygen scavenger materials in the parts of the cap touching or close to the product for example on an internal end surface of the plug 92.

It will be appreciated that the constructions described allow the production of a cap with an effective gas barrier that also has a functional long valve 20 suitable for sealing carbonated beverages.